The regrettable substitution of GenX for PFOA

Abstract

After the discovery that many PFAS were PBT in the early 2000s, the USEPA and other regulatory authorities made efforts to require industries to reduce and/or eliminate the production and use of "long-chain" PFAS. Because the USEPA's Stewardship Program sought the elimination of all long-chain PFAS by 2015, participating companies were motivated to introduce a new generation of PFAS that did not fit the "long-chain" classification but allowed them to maintain production, market share, and profit.

Companies soon introduced a range of new substitute PFAS that were specifically tailored to these needs. DuPont, which had been using PFOA as a processing aid for fluoropolymer production, sought approval to use an ammonium perfluoro (2-methyl-3-oxahexanoate, CAS # 62037-80-3)-based process called GenX, for fluoropolymer production.

USEPA and REACH approved this substitution after review of a small number of animal studies and other laboratory and modeling efforts describing the environmental fate, potential for bioaccumulation, and toxicity. These data show that while GenX has a shorter half-life than PFOA in test animals, it is persistent in the environment and is associated with a range of health effects that are strikingly similar to PFOA.

GenX has now been measured in surface water in a number of locations worldwide and initial studies demonstrate that it is poorly removed during conventional drinking water treatment processes. One recent study in North Carolina has measured GenX in finished drinking water at over 4000 ng/L, or more than 50 times higher than the current health advisory level of 70 ng/L for PFOA.

This paper explores how this substitution was made and calls into question the wisdom of the regulatory apparatus that consistently allows regrettable substitutes to be made.

This work highlights the need to critically examine the safety of all PFAS substitutes currently in use

Also makes a case for a class based regulatory approach based on the Principle of Precaution

Introduction

With ongoing concerns about the toxicity and persistence of legacy PFAS such as PFOA and PFOS, many new PFAS have been brought to market to take the place of the legacy long chain PFAS.

The use of these new PFAS has been permitted by many different regulatory entities worldwide and there is now a growing body of literature documenting the presence of these materials in the environment and humans.

Despite the time and expense required to put this global substitution program into place, there is still surprisingly little information on whether these new compounds are actually less of a concern for humans and the environment. In this review we ask if new PFAS significantly differ from the legacy materials they are designed to replace.

The limited information available indicates that the replacements are generally still persistent in the environment, they may have significant half-lives in animals and humans, and may have toxicity that is similar to the legacy materials. Research is also indicating that many new PFAS are not effectively removed using conventional drinking water treatment methods.

Ammonium perfluoro (2-methyl-3-oxahexanoate) (GenX, CAS # 62037-80-3) is a known replacement for PFOA that has been widely used in the production of polytetrafluoroethylene (PTFE or Teflon). It has recently been confirmed as a contaminant in surface water in Europe and the US and it has been measured in finished drinking water at concentrations as high as 4,500 ng/L (Sun et al., 2016).

In this paper we examine the case of GenX, first focusing on the regulatory process that permitted it's use in the US. We discuss how and why production was permitted in 2009 by the Toxic Substances Control Act (TSCA) and argue that the recently enacted Lautenberg Chemical Safety Act (TSCA amendments) of 2016 would likely not approve it as a viable PFOA substitute. We also review of some of the key literature concerning its toxicity and discuss how it is similar to PFOA in terms of carcinogenicity. We finish with an analysis of the literature documenting the occurrence of GenX and some other replacements in the environment and examine the implications of our current policies regarding use of PFAS substitutes. Finally, we use this case to argue more broadly that PFAS should be managed as a class and that a truly protective policy would exclude the use of these materials substantially.

Methods

The Stewardship Agreement between USPEA and 8 major PFAS production companies called for a complete phase out of all long-chain PFAS by 2015.

Alternative replacement PFAS were reviewed and approved for use by EPA.

In 2009 when GenX was "approved" under TSCA, EPA was required to approve compounds submitted to the premanufacture notice (PMN) process unless it could definitively demonstrate that a compound would present a risk. Potential risk was evaluated using conventional models like Epi Suite and by making inferences from data published on compounds with similar structures and function. No actual testing to empirically determine transport and fate, environmental persistence, bioaccumulation potential, or toxicity was required. Production thresholds? What can you specifically say about the review of GenX under old TSCA?

From WV DEP document:

"The U.S. EPA, through a Toxic Substances Control Act Section 5(e) Consent Order ("TSCA Order") executed by DuPont on January 28, 2009, granted DuPont approval, under conditions set forth in the TSCA Order, to commercially manufacture, process, and distributes the processing aid. The TSCA Order requires that DuPont shall recover and capture (destroy) or recycle the New Compound "at an overall efficiency of 99% from all the effluent streams and the air emissions (point source and fugitive)." This requirement is interpreted by DuPont to be applied in the aggregate on an annual basis, for all U.S. sites where the New Compound is used. The wastewater treatment system for the Facility's fluoropolymers processes will be modified to achieve the TSCA Order requirements at present and future production capacity."

After EPA approved GenX, the West Virginia DEP issued a permit for it discharge from the Washington Works facility in Parkersburg provided that concentrations in the receiving body of water did not exceed 17,500 ng/L. (Also note that in 2009 the WVDEP limit for PFOA in surface water was ?500 ng/L?)

Discussion of how GenX is used in the PTFE production process. How GenX is recovered and what kinds of emission are known to occur

Results Discussion

The information submitted to the USPEA to obtain approval for GenX is classified as Confidential Business Information (CBI) and is therefore not available for inspection

The REACH dossier on GenX is a summary of the submitter's conclusions based on the studies they have done (can we get these studies?) https://echa.europa.eu/registration-dossier/-/registered-dossier/2679/1

And how were these studies designed? The Dutch RIVM document states:

"The requirement of STOT RE 2 (like liver and kidney) is difficult to assess due to dose levels tested in mice clearly below the guidance values, which may be taken as an indication that STOT RE 2 is needed. The effects in the rat are borderline and difficult to assess due to the large steps in the dose levels. Effects on the liver are observed at the similar dose levels for FRD-902 (ammonium salt) and PFOA."

So were the studies designed (or reported) to provide just enough information for approval while also limiting potential concerns?

Review of Physical chemical properties, degradation, and potential for bioaccumulation

"Regarding all available data on degradation, bioaccumulation, and toxicity it can be stated that the substance does not fulfill the PBT criteria (not PBT) nor does it fulfill the vPvB criteria (not vPvB)."

"P not vP
Based on the results of a ready biodegradation test and current knowledge of highly fluorinated substances, the test substance is expected to persist if released to the environment."

"not B/vB

Based on the high water solubility and log KD of 2.58, as well as the observed lack of bioaccumulation during a bobwhite quail reproduction study, the test substance does not meet the criteria of revised Annex XIII and is not B and not vB."

Persistence

"A hydrolysis study (OECD 111) demonstrated that the test substance was hydrolytically stable (half-life > 1 year) at environmentally relevant pHs. Other abiotic degradation studies, such as phototransformation studies in air, water, and soils, are not required at the 10-100 t/a volume band.

The test substance is not Ready Biodegradable based on the results of a ready biodegradation test (TG OECD 301B).

The test substance is hydrolytically stable and not ready biodegradable. The test substance is expected to be not biodegradable. The rate constant (k) for elimination in sewage treatment plant is 0 (h-1).

Simulation testing in water and sediments and biodegradation testing in soil are not required at the 10-100 t/a volume band."

"The hydrolytic stability of the test substance was evaluated at pH 4, 7, and 9, at 50°C over a five day period. No degradation was evident in triplicate samples prepared in pH 4, 7, and 9 buffer solutions after a five day incubation period at the elevated temperature. Therefore, no further work was done."

"The test substance is not Ready Biodegradable based on the results of a ready biodegradation test (TG OECD 301B). The test substance is expected to be not biodegradable. The rate constant (k) for elimination in sewage treatment plant is 0 (h-1). The table below lists the various degradation rates."

“Although the results of the in vitro trout hepatocyte study suggest the test substance is not metabolized by fish, the high water solubility and low Koc of the test substance indicate it is unlikely to be a concern for aquatic bioaccumulation.

Tissue residue measurements from a Japanese quail reproduction study demonstrate the test substance is not a concern for terrestrial bioaccumulation.”

“Henry Law Constant (H) of 4.06E-06 Pa-m3/mole was calculated using Equation R.16-4 in Chapter R.16.5.3.2 and measured vapour pressure and water-solubility values. For chemicals with H values less than 0.01 Pa m3/mole, the chemical is less volatile than water. As water evaporates, the concentration of the chemical in the aqueous phase will increase. However, the degree of volatilization of substances from the aquatic environment is highly dependent on the environmental parameters for the specific water bodies in question, such as the depth and the gas exchange coefficient. The test substance emitted to water is expected to remain in the water phase. The test substance emitted to soil is expected to partition to water and have a high to very high mobility to round water due to its low volatility and low adsorption to soil (low Koc). The test substance emitted to air is expected to partition to water in the air and return to the ground through wet-deposition.”

Terrestrial Toxicity

"Applicant's summary and conclusion

There were no treatment-related mortalities, overt signs of toxicity or treatment related effects upon body weight or feed consumption at any tested concentrations. Additionally, there were no treatment-related effects upon reproductive performance parameters measured at the 100, 500 or 1000 ppm test concentrations. The no-observed-effect concentration (NOEC) for northern bobwhite quail exposed to the test substance in the diet during this study was 1000 ppm (equivalent to 84.5 mg/kg/day), the highest nominal test concentration and the lowest observed effect concentration (LOEC) was > 1000 ppm (equivalent to > 84.5 mg/kg/day)."

Toxicity issues for GenX (specifically cancer) are known:

Chronic bioassay in male and female rats published in peer-reviewed journal (this study may have been requested in the consent order with EPA)

Caused same 3 tumor types as PFOA (liver, testicular, pancreatic)

As stated in paper, these 3 types are also caused by some other PPAR-alpha activators that are unrelated to PFAS

In a letter to EPA, it was stated that the tumors are not relevant to human risk assessment because of lack of genotoxicity, the high dose at which tumors occur, and because these PPAR-alpha associated tumors are relevant to rats but not humans.

EPA apparently accepted this explanation, since no follow-up mode of action studies were requested and no other actions were required.

But for PFOA, there has already been extensive evaluation of the mode of action of these 3 tumor types.

EPA Guidelines for Carcinogen Risk Assessment include default assumptions:

One of default assumption is that tumors in animals are considered relevant to humans unless it is **conclusively** demonstrated that the mode of action is not relevant to humans.

Another default assumption is that low-dose extrapolation (i.e. a cancer slope factor approach) should be used unless mode of action studies conclusively demonstrate that the tumors occur through a threshold mechanism that is not relevant at low doses.

Mode of action studies of PFOA and GenX have not demonstrated that the 3 tumor types are **not** relevant to humans or that they occur only at high doses through a threshold mode of action.

The EPA Office of Water and NJ DWQI have developed slope factors for tumors caused by PFOA.

There appears to be a disconnect/inconsistency between different parts of USEPA on this issue.

The GenX chemical was approved for use without mode of action studies showing tumors are not relevant to humans.

However, if this chemical has been detected in environmental media (e.g. soil, water) and a health-based guidance or standard needs to be developed, EPA risk assessment guidelines require information on mode of action of tumors before a conclusion that they are not relevant to humans can be made.

Include some discussion of the more general issue of the approval of many PFAS replacements based on similarly limited data.

If GenX was submitted today the PMN would be reviewed under the Lautenberg Chemical Safety Act (new TSCA). New TSCA requires that approval is withheld until it can be concluded that a new chemical presents no risk. So GenX would almost certainly not be approved for production today

Summary of GenX measurements worldwide

Permit to discharge in West Virginia – no monitoring program but limit of 17,500 ng/L allowed

Netherlands

North Carolina

Sun et al., 2016 found GenX in finished drinking water at approximately 4,500n g/L. Detailed process specific testing at the drinking water plant showed removal during the treatment process.

Others?

Conclusions

May new PFAS substitutions have been made in recent years.

In the case of GenX, the chemical structure is different than PFOA, only obvious advantage is shorter biological half-life in some species.

But:

Like PFOA, does not break down in the environment.

And larger amounts may need to be used in industrial processes to achieve same effect as PFOA.

Not detected by routine analytical methods, so difficult to study environmental occurrence

New TSCA would probably not allow production of GenX

We have made another “regrettable substitution” and should take steps to:

Restrict GenX

Change regulatory process that institutionalizes regrettable substitutions